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The Panel of Managers holds regularly scheduled meetings that are open to the public. Technical Working Group and committee meetings are scheduled on an as-needed basis, and are also open to the public. Meetings are generally held at the National Oceanic and Atmospheric Administration, National Marine Fisheries Service - Regional Directorate Conference Room, Building #1, 7600 Sand Point Way, NE, Seattle. The Panel recommends that you contact the Administrative Director at the above phone number to confirm meeting schedules and locations. The Panel also holds periodic special evening and weekend public information meetings and workshops.

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Report cover photographs provided by King County Department of Natural Resources photograph files. Upper photo: Speckled Sanddab (*Citharichthys stigmaeus*), middle photo: Epibenthic Suction Pump, lower photo: *Cumella vulgaris*.

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Introduction

The Elliott Bay Nearshore Substrate Enhancement Project was implemented in March 1998 pursuant to a decision made by the Elliott Bay/Duwamish Restoration Program (EB/DRP)¹ Panel of Managers to undertake a substrate enhancement project in the West Seattle nearshore area as described in the 1994 Concept Document (EB/DRP, 1994). Investigations of the nearshore areas in the vicinities of Myrtle Edwards Park, Seacrest Marina, and Duwamish Head during 1996 resulted in the selection of two sites for substrate enhancement: Site #1, referred to as Duwamish Head, and Site #2, referred to as "Seacrest area" (See Figure 1)².

The substrate enhancement project was undertaken to improve nearshore marine habitat conditions by enhancing productivity of benthic infauna, increasing the distribution and density of macro algae and other primary producers, and improving the attributes that support resident and migratory marine and estuarine fish species. Habitat objectives included the following:

- ♦ Increase diversity of bottom substrates;
- ♦ Increase area of limiting hard bottom substrates;
- ♦ Provide intertidal substrates for bait fish spawning;
- ♦ Provide suitable substrates at proper horizons for eelgrass;
- ♦ Increase volume of physical and protective structures for juvenile and adult resident invertebrates and fishes;
- ♦ Increase hard structure surfaces for macro algae; and
- ♦ Remove undesirable bottom debris.

¹ The Elliott Bay/Duwamish Panel of Managers was established to implement terms of the Consent Decree arrived at by and between federal, Tribal and state natural resource trustees and the City of Seattle and Municipality of Metropolitan Seattle (now King County Department of Natural Resources) pursuant to United States of America v. the City of Seattle and Municipality of Metropolitan Seattle, No. C90-395WD (W.D. Wash.).

²Site #2 is identified as Site #3 in the permit application (Appendix B); however, it has been relabeled as Site 2 for ease of communication because no enhancement activities occurred on the site originally designated as Site #2. The "Seacrest Marina area" identified in the permit application is referred to as the Seacrest area in this plan because the marina was removed in the late 1970s.

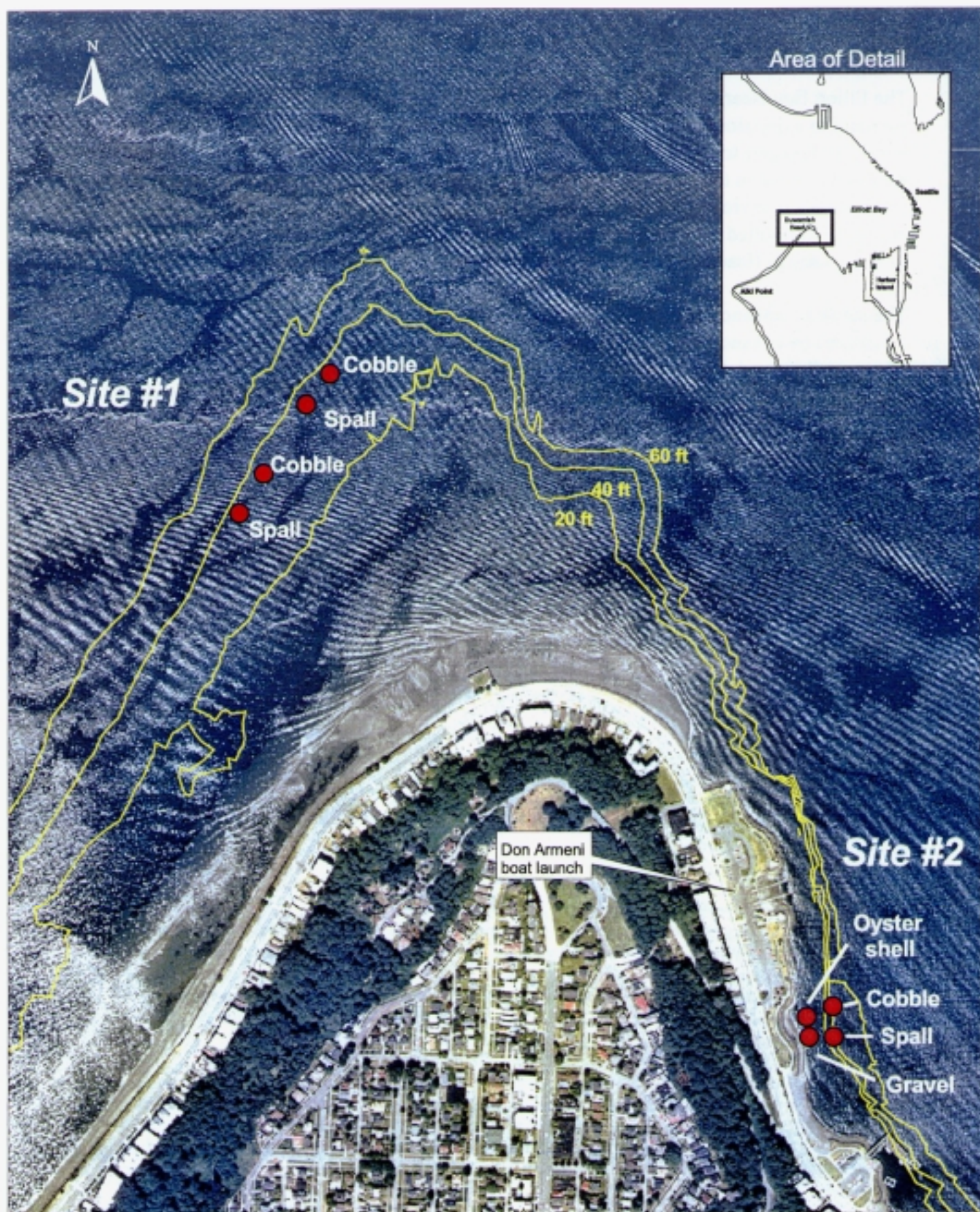


Figure 1. Elliott Bay Nearshore Substrate Enhancement Project Location

Site Conditions Prior to Project Implementation

As part of the site selection process, the Panel engaged the Washington Department of Fish and Wildlife (WDFW) to conduct an assessment of physical and biological parameters of potential project locations (Resolution 1995-26).

Substrate in the Duwamish Head project area (Site #1) was described by WDFW as stable and suitable with high potential for a "significant increase in the biodiversity and densities of species in the Elliott Bay area resulting from benthic habitat enhancement..." (Buckley, April - May 1996). A checklist of the variety of species found at Duwamish Head appears in Appendix A (Table A-1).

The subtidal (offshore) area north of Seacrest Park (Site #2), with variably sloping substrate and some shelf areas, was also judged to have a favorable physical profile and potential for high biodiversity. The biological checklist of species found at the site is provided in Appendix A (Table A-2). Paul Dinnel, Dinnel Marine Research (DMR), recommended small scale oyster shell plots in the intertidal (nearshore) area for the creation of juvenile Dungeness crab nursery habitat (Dinnel, 1993).

The Panel selected King County Department of Natural Resources (King Co. DNR) as the Project Manager for the development of a plan, schedule and budget for the enhancement project (Resolution 1996-31) and for project implementation (Resolution 1997-13). Three major factors influenced project design. A contaminated area north of the Seacrest area designated by the Washington Department of Ecology (Ecology) as EB3 initially posed concerns and significant design constraints. However, by 1997, Ecology determined that the "hot spot" containing mercury, benzoic acid, and copper, among other contaminants, was no longer a problem due to the process of natural recovery. Oyster shell enhancement could not occur in the intertidal area due to City of Seattle concerns about activities that might result in the concentration of additional recreational divers in shoreline areas already impacted by diver activities. Project design was also influenced by the Panel's desire to minimize restrictions on commerce, navigation, tribal and sport fishing.

The Washington Department of Natural Resources (WDNR) granted a right of entry for the substrate enhancement treatments for state aquatic lands northwest of Duwamish Head and seaward of City of Seattle tidelands north of Seacrest Park in West Seattle, extending outward from SW Atlantic Street (See Appendix B).

Project Design and Implementation

The Joint Aquatic Resource Permits Application (JARPA) was submitted to the U.S. Army Corps of Engineers in January 1998 (see Appendix C). The project was approved under a Nationwide Permit, and was constructed in early March 1998. The U.S. Army Corps of

Engineers, together with King County DNR, placed cobble, quarry spall, pea gravel and oyster shell in designated locations (See Figure 2). Materials were deployed by barge and placed in separate plots through the use of a crane and clamshell bucket. Project consultant Paul Dinnel participated in the placement of oyster shell.

Site #1

Cobble and spalls were placed at Site #1 - Duwamish Head. Four treatments of approximately 5 cubic yards each were placed near the -35' mean lower low water (MLLW) bathymetric contour. Each plot measured 10' x 10', less than 18" high. Protocols called for placing one treatment of cobble and one treatment of spall from above the water surface, and one treatment of cobble and one treatment of spall from below the water surface. During construction, however, all treatments were placed from above water.

Site #2

Oyster shell, cobble, quarry spall and pea gravel were placed in subtidal plots at Site #2 located just north of Seacrest Park, seaward of the Seattle tidelands, extending outward from SW Atlantic Street (See Figures 1 and 2). About 5 cubic yards of oyster shell were deployed over an area roughly 10' x 20', with a shell layer depth of about 6" at a depth of -2' to -12' MLLW. The oyster shell plot and eelgrass control site are shown in Figure 3.

A 10' x 20' x 6" high plot of pea gravel (5 cubic yards) was placed near the -2' to -10' MLLW contour. One plot of cobble and one plot of quarry spall, each about 5 cubic yards, approximately 10' x 10', were placed near the -35' MLLW bathymetric contour. Each plot contains rocks ranging in size from 2" to 12", with an average 12" thickness and height less than 18".



Cobble

Quarry spall



Oyster shell

Pea gravel



Figure 2. Project Materials (photographs courtesy of U.S. Army Corps of Engineers)

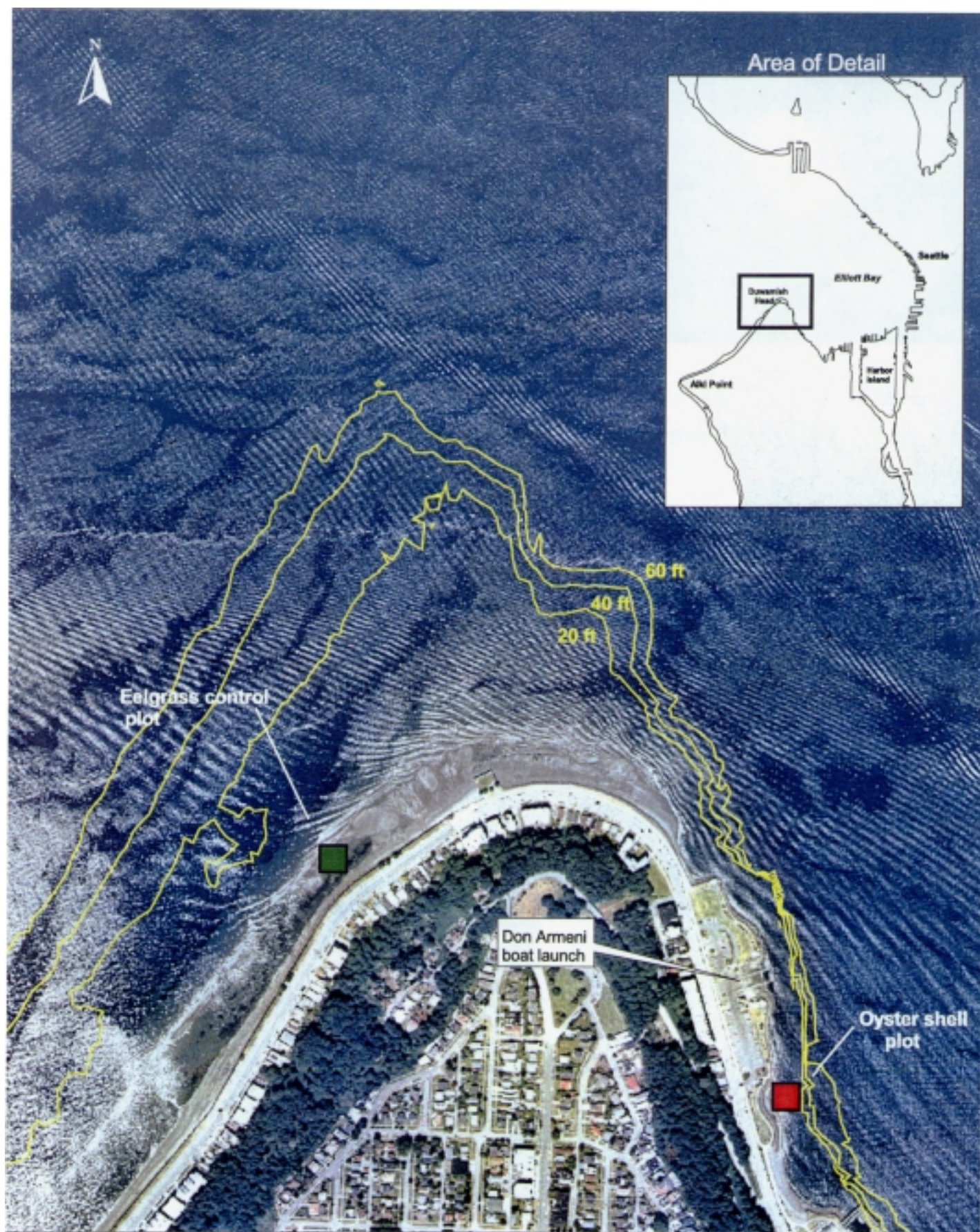


Figure 3. Oyster Shell and Eelgrass Control Plot Locations for Juvenile Dungeness Crab Survey

Monitoring Schedule, Methods and Budget

Project monitoring is necessary to assess the stability of substrate enhancements and determine the extent to which enhancements result in an increase in macroalgae, macroinvertebrates, juvenile and adult migratory and resident fish, juvenile Dungeness crab, and non-prey and prey benthos preferred by juvenile salmonids. A summary of the monitoring schedule is provided in Table 1.

Monitoring Schedule

Table 1 provides a summary of the monitoring schedule, events and budget.

Physical observations of all treatments will occur four times during the first year of substrate placement, and subsequently, in years two, three, four and five during February and August, at a minimum.

Biological sampling of the pea gravel plot will occur at least once per year in years one, two, three and five, anytime during April through early May. A second sampling event will be scheduled during June of each year as resources permit.

Biological sampling of the oyster shell plot will occur in July in year one and possibly in year three, dependent upon an evaluation of year one results.

Monitoring Methods

Three primary monitoring methods will be used for both project sites: physical observation (video monitoring), epibenthic invertebrate sampling, and juvenile Dungeness crab assessment. Species diversity and abundance at both sites #1 and #2 will be determined by physical observation. In addition, the pea gravel plot at site #2 will be sampled for epibenthic fauna and the oyster shell plot will be sampled for juvenile Dungeness crab settlement.

Physical observations of all treatments will be made with remote control camera and/or with diver and video camera. Monitoring reports will provide information on the areal extent and configuration of substrate, accumulation of sediment, and qualitative data of species diversity and abundance.

Biological sampling of the pea gravel plot to determine juvenile salmonids prey resources production will entail taking a minimum of 10 epibenthic samples with a gas powered centrifugal water pump, sucked through a 15 meter (m) long (51 millimeter [mm] inner diameter) hose connected to a terminal head attachment .35m wide and .38m high. Five samples will be collected from the gravel plot and five samples will be collected from an adjacent untreated substrate which will serve as a control, at an average tidal height of -22" MLLW. Samples will be preserved in 10% buffered formalin and transferred to 70% alcohol once back at the laboratory.

Samples will be processed by University of Washington, Fisheries Research Institute - Wetland Ecosystem Team (UWFRI-WET).

The oyster shell plot will be sampled during July of designated years using a hand-held venturi suction dredge. Ten samples will be collected on each date from the plot by working the nozzle of the suction dredge between the oyster shells within a $1/4 \text{ m}^2$ metal frame. By this method, crabs and associated fauna are sucked into a mesh bag, which will be exchanged for a new bag at the end of each sample effort. Samples will be sorted, identified and measured; other organisms will be identified to major taxonomic group, and animals returned live to the bay. Ten samples will be collected on each date from eelgrass beds representing the control site on the northwest side of Duwamish Head (See Figure 1). Control samples will be collected intertidally at low tide by digging $1/4 \text{ m}^2$ quadrat samples to a depth of about 2 centimeter (cm) and washing the samples in a mesh bag with mesh size of about 3 mm.

Monitoring Program Budget

Prior to construction, the Panel approved an allocation of \$40,000 for the implementation of the monitoring program. The monitoring budget is provided in Table 1.

Monitoring Program Management and Implementation

As the project manager, King County DNR is responsible for the management and implementation of the monitoring program. Where practicable, volunteer community stewards will be invited to participate in determining physical success. Contractors for sampling activities to determine biological success will be selected by King County DNR and approved by the Panel. Modifications in the monitoring plan may be made by the project manager and the Panel.

Monitoring Reports

Monitoring report summaries will be provided to members of the Panel and the Habitat Development Technical Working Group no later than one year following sampling events and observations. Full reports will be provided within one year of the sampling events and observations. Monitoring reports are also available to interested members of the public upon request.

Table 1.

**Elliott Bay Nearshore Substrate Enhancement Project
Monitoring Schedule and Budget**

Monitoring Type/Project Site	Year/Frequency - Estimated Costs					Comments
	1 (1998) annual	2 (1999) semi- annual	3 (2000) semi- annual	4 (2001) semi- annual	5 (2002) semi- annual	
Physical Attributes						
Sites 1 & 2 erosion	\$ 50	\$ 50	\$ 50	\$ 50	\$ 50	Scuba supplies
	\$ 2,461	\$ 1,753	\$ 1,000	\$ 1,000		Sampling costs
			\$ 126			Computer software
Biological Attributes	1 annual	2 annual	3 semi- annual	4 semi- annual	5 semi- annual	Comments
Site #2 (oyster shell)						
juvenile Dungeness crab presence	\$ 6,140	\$ 6,200 reserved	-	-	-	Monitoring in year 2 will occur if warranted
Site #2 (pea gravel)	\$ 1,200	\$ 1,000	\$ 4,600	-	\$ 4,600	Consultant
Salmonid Prey	\$ 616	\$ 584	\$ 1,000	-	\$ 1,000	Sampling costs
Total Projected Monitoring Costs	\$ 10,648	\$ 3,387	\$ 6,776	\$ 1,050	\$ 6,650	\$28,331 plus \$6,200 reserved

Appendix A

Table A-1. Checklist of species found at Duwamish Head, Site #1, 1996. (Buckley)

Table A-2. Checklist of species found at Seacrest nearshore area, Site #2, 1996. (Buckley and Bookheim)

Table A-1. Checklist of species found at Duwamish Head, Site #1, 1996.

Fish	Echinodermata (continued)
Big skate (<i>Raja binoculata</i>)	Ochre sea star (<i>Pisaster brevispinus</i>)
Shiner perch (<i>Cymatogaster aggregata</i>)	California sea cucumber (<i>Parastichopus californicus</i>)
Puget Sound sculpin (<i>artedius meanyi</i>)	White sea cucumber (<i>Eupentacta quinquesemita</i>)
Painted greenling (<i>Oxylebius pictus</i>)	Cnidaria
C-O sole (<i>Pleuronectes coenosus</i>)	White plumed anemone (<i>Metridium giganteum</i>)
Mollusca	Anemone (<i>Metridium senile</i>)
Gumboot chiton (<i>Cryptochiton stelleri</i>)	Painted anemone (<i>Urticina crassicomis</i>)
Lined chiton (<i>Tonicella lineata</i>)	Sand-rose anemone (<i>Urticina columbiana</i>)
Black chiton (<i>Katharina tunicata</i>)	Sea pen (<i>Ptilosaris gurneyi</i>)
Nudibrach (<i>Armina californica</i>)	Annelida
Purple olive (<i>Olivella biplicate</i>)	Polychaete worm (<i>Mesochaetopterus taylori</i>)
Wrinkled amphissa (<i>Amphissa columbiana</i>)	Northern feater duster worm (<i>Eudistylia vancouveri</i>)
Rock oyster (<i>Pododesmus macroschisma</i>)	Serpulid worm (<i>Serpula vermicularis</i>)
Gaper clam (<i>Tresus sp.</i>)	Angiosperms
Piddock (<i>Zirfaea pilsbryi</i>)	Eelgrass (<i>Zostera marina</i>)
Heart cockle (<i>Clinocardium nuttalli</i>)	Algae
Native littleneck clam (<i>Protothaca staminea</i>)	Navicula
Bay mussel (<i>Mytilus edulis</i>)	<i>Laminaria saccharina</i>
Horse mussel (<i>Mytilus edulis</i>)	<i>Nereocystis leutkeana</i>
Arthropoda	<i>Alaria marginata</i>
Northern kelp crab (<i>Pugettia producta</i>)	<i>Pterygophora californica</i>
Graceful kelp crab (<i>Pugettia gracilis</i>)	<i>Desmarestia ligulata</i>
Red rock crab (<i>Cancer productus</i>)	<i>Iridea cordata</i>
Coonstripe shrimp (<i>Pandalus danae</i>)	<i>Gigartina exasperata</i>
Acorn barnacle (<i>Balanus glandula</i>)	<i>Gracilaria sjoestedtii</i>
Echinodermata	<i>Ahnfeltiopsis pacifica</i>
Brittle star (<i>Ophiopteris papillosa</i>)	<i>Sarcodiotheca gaudichaudii</i>
Sunflower star (<i>Scynopodia helianthoides</i>)	<i>Callophyllis sp.</i>
Rose star (<i>Crossaster papposus</i>)	<i>Opuntiella californica</i>
Sand star (<i>Luidia foliolata</i>)	<i>Delessaria decipiens</i>
False ochre sea star (<i>Evasterias troschelli</i>)	

Source: Buckley, undated)

Table A-2. Checklist of Species found at Seacrest nearshore area Site #2, 1996.

Fish	Arthropoda (continued)
Tubesnout (<i>Aulorhynchus flavidus</i>)	Red rock crab (<i>Cancer productus</i>)
Wolf-eel (<i>Anarrhichthys ocellatus</i>)	Graceful crab (<i>Cancer gracilis</i>)
	Hermit crab (<i>Pagurus armatus</i>)
Pacific herring (<i>Clupea harengus pallasii</i>)	Coonstripe shrimp (<i>Pandalus danae</i>)
Brown rockfish (<i>Sebastes auriculatus</i>)	Annelida
Copper rockfish (<i>Sebastes cauprinus</i>)	Feather duster worm (<i>Eudistylia polymorpha</i>)
Quillback rockfish (<i>Sebastes maliger</i>)	Polycheate (<i>Mesochaetopterus taylori</i>)
Lingcod (<i>Ophiodon elongates</i>)	Echinodermata
Whitespotted greenling (<i>Hexagrammos stelleri</i>)	Sunflower star (<i>Psycropodi halianthoides</i>)
Sculpin (<i>Artedius sp.</i>)	Stimpson's sun star (<i>Solaster stimpsoni</i>)
Buffalo sculpin (<i>Enophrys bison</i>)	Rose star (<i>Crossaster papposus</i>)
Sailfin sculpin (<i>Nautichthys oculofasciatus</i>)	Sand star (<i>Luidia foliolata</i>)
Kelp perch (<i>Brachyistius frenatus</i>)	False ochre star (<i>Pisaster ochraceus</i>)
Pile perch (<i>Rhacochilus vacca</i>)	Cushion star (<i>Pteraster tessellatus</i>)
Shiner perch (<i>Cymatogaster aggregata</i>)	California sea cucumber (<i>Parastichopus californicus</i>)
Striped perch (<i>Embiotoca lateralis</i>)	Cnidaria
Speckled sanddab (<i>Citharichthys stigmaeus</i>)	White plumed anemone (<i>Metridium giganteum</i>)
Rock sole (<i>Lepidopsetta bilineata</i>)	White spotted rose anemone (<i>Urticina lofotensis</i>)
C-O sole (<i>Pleuronichthys coenosus</i>)	Sand-rose anemone (<i>Urticina columbiana</i>)
Mollusca	Aggregating anemone (<i>Anthopleura elegantissima</i>)
Giant Pacific octopus (<i>Octopus dofleini</i>)	Water jellyfish (<i>Aequorea aequorea</i>)
Stubby squid (<i>Rossia pacifica</i>)	Lion's mane jellyfish (<i>Cyanea capillata</i>)
Market squid (<i>Loligo opalescens</i>)	Fleshy sea pen (<i>Ptilosarcus gurneyi</i>)
Lewis' moon snail (<i>Polinices lewisii</i>)	Macro-algae
Gaper clam (<i>Tresus capax</i> or <i>nuttallii</i>)	Navicula sp.
Bay mussel (<i>Mytilus edulis</i>)	Sargassum muticum
Nudibrach (<i>Flabellina fusca</i>)	Laminaria saccharina
False sea lemon (<i>Archidoris montereyensis</i>)	Sarcociotheca sp.
Arthropoda	Sarcodiotheca sp.
Acorn barnacle (<i>Balanus glandula</i>)	Callophyis flabellulata
Northern kelp crab (<i>Pugettia producta</i>)	Opuntiella californica
Dungeness crab (<i>Cancer magister</i>)	

Source: Buckley and Bookheim